Monitoring Local and Global Contaminants in Alaska Parks

By Dave Schirokauer and Brendan Moynahan

Vast stretches of tundra, extensive forests and ranges of glacier-clad peaks evoke visions of wildlands untouched by the effects of major industrial development. Unsurprisingly, people assume that industrial contaminant levels in Alaska parks are among the lowest in the world. However, a recently completed assessment revealed that Alaska parks are not immune from the effects of global industrialization (*Landers et al. 2008*). Several "Persistent Organic Pollutants" (POPs) such as pesticides, flame retardants, and mercury, have been detected in biota, air, and waterways thousands of miles from use or emission sources.

Many persistent contaminants arrive in remote Alaska parks through atmospheric transport, oceanographic processes, and by way of fish and wildlife. Contaminants can become concentrated at northern latitudes due to patterns of atmospheric circulation and global distillation – phenomena by which POPs and mercury deposited at warmer, lower latitudes revolatize and travel in the atmosphere towards cooler, higher latitudes. A recent study (*Sunderland et al. 2009*) demonstrated that elemental mercury deposited in ocean waters near industrial areas was transformed into the more toxic methylmercury and transported on prevailing currents to distant coastal areas. Coastal Alaska is identified as a receptor of mercury and POPs delivered both by ocean currents and atmospheric processes. Many of these compounds are fat soluble and accumulate in fish and wildlife. The longer-lived and higher on the food chain an organism is, the higher the potential contaminant concentrations. Local, regional, and global air pollutants are a concern because of the potential adverse effects on human health and sensitive components of national park ecosystems.


NPS photograph

Figure 1. Mussel bed (*Mytilus trossulus*) in Glacier Bay National Park and Preserve.

Some pollutants – such as sooty fine particles and nitrogen oxides from transportation sources – exhibit dramatic local increases during the summer tourist season. Glacier Bay NPP (GLBA) permitted 225 visits from large cruise ships in 2009, and Skagway, the home of Klondike Gold Rush NHP (KLGO), is now the 16th busiest cruise ship port in the world. In 2009, up to five large cruise ships docked in Skagway daily from May to September. Diesel-powered tourist trains depart Skagway for White Pass and beyond, traversing KLGO and the Tongass National Forest several times daily.

In response to these issues and concerns, the Inventory and Monitoring Networks (I&M) in the region are developing a multi-pronged approach to monitor trends in environmental contaminants. Highlights include the new National Atmospheric Deposition Monitoring (NADP) site in Katmai NPP, and several vital signs focused on monitoring contaminant levels in biota including non-anadromous lake fish, moss, lichens, and marine mussels.

Mussels as marine sentinels

Oceans receive pollutants both through direct discharge (including vessel discharges, exhaust, and spills) and through deposition from airborne and terrestrial sources. Bay mussels (*Mytilus trossulus*) and blue mussels (*Mytilus edulis*) are common, long-lived (20 years), immobile organisms that accumulate contaminants. Both species are the subject of the longest running contaminant monitoring program in the country, the two decade-long Mussel Watch program (*Kimbrough et al. 2008*).

Marine contaminants in bay mussels were selected as a monitoring vital sign in Southeast Alaska Network (SEAN) and Southwest Alaska national parks. Sixty-three mussel monitoring sites have been assessed, and a small subset of these sites were selected for long-term monitoring. These sites will allow NPS biologists to detect local pollution sources, track impacts of catastrophic unintended releases (such as oil spills), and track changes in global background levels of contaminants.

Currently POPs, hydrocarbon and mercury levels in the Alaska park samples are among the lowest in the country (*Tallmon 2009*); however, DDT, chlordane, and PCBs (compounds that have not been used in the U.S. for decades) have been detected in some samples. Sites associated with heavy human activity have higher levels of some contaminants relative to most sampling sites. At all sites, mussel and sediment samples have levels of contamination that are almost uniformly well below values considered human health threats. The recent mussel sampling serves as a reference for detecting changes; some sites will be re-sampled on a rotating basis.

Mercury and POPs in freshwater systems

In 2006 and 2007, SEAN cooperators at the University of Alaska Southeast sampled juvenile coho salmon (*Oncorhynchus kisutch*), sediments, water, and macro-invertebrates in several rivers throughout the SEAN parks (*Nagorski et al. 2009*). Mercury and several POPs were detected in all of the sampled watersheds.

Elemental mercury is not generally accumulated and biomagnified by fish until it is converted by microbial activity into methylmercury. Although numerous dynamics control methylation rates, one factor is the extent of peat-rich wetlands in a watershed. When GLBA watersheds were assessed based on the time since glaciation, methylmercury levels in stream water particles, macro invertebrates, and juvenile fish were correlated with stream system age and wetland extent. The older the watershed, the more wetlands there are, and thus the higher the methylmercury concentration. This spatial pattern was not evident for the POPs (*Nagorski et al. 2009*). Juvenile coho salmon have not yet departed from their natal streams, so any tissue contaminants would be from local sources. Fish less than one-year old generally had relatively low concentrations of mercury; however, in some older watersheds, juvenile coho salmon greater than one-year old had mercury levels of 80 ng/g, which approaches or exceeds the threshold for the protection of some species of fish-eating wildlife (*Lazorchak et al. 2003*).

Several Alaska parks are monitoring mercury. GLBA and Gates of the Arctic NPP collected wet mercury deposition data weekly. Total (wet and dry) deposition is being assessed in lichen tissue at Southeast Alaska parks and in moss tissue at Cape Krusenstern National Monument. Lake sediments, which provide a historical record of deposition, are being analyzed for mercury and other persistent contaminants in parks throughout the region. Resident lake fish, known to bioaccumulate methylmercury, are being assessed at

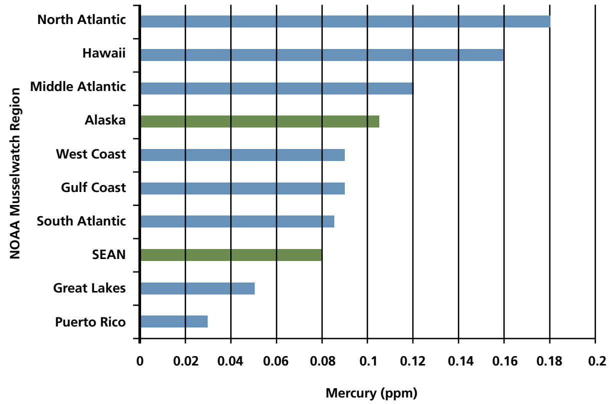

Figure 2. Mercury in mussels within SEAN parks is lower than most regions in the US, according to the NOAA Mussel Watch program data set.

Noatak National Preserve and Katmai, Lake Clark, and Gates of the Arctic National Parks and Preserves.

Atmospheric chemistry and lichens

To complement assessment and monitoring of marine and freshwater contaminants, deposition of airborne contaminants on terrestrial habitats is also monitored by Alaska I&M programs. SEAN is assessing several ways of monitoring atmospheric chemistry, including: elemental analysis of lichen tissues, passive sensors that measure weekly average ambient concentrations of various oxides of nitrogen and sulfur, passive sensors that measure terrestrial deposition of nitrogen and sulfur on a seasonal basis, and arboreal lichen community composition. Passive chemical sensors and lichens are being used simultaneously to create models that relate signals in lichen community change and elemental concentration in tissue samples with known, quantifiable atmospheric conditions.

Lichens are useful as both short-term bio-samplers for some contaminants that are seasonally associated with human activity and for other more persistent contaminants. Lichens are long-term integrators of atmospheric deposition due to their longevity and lack of inter-seasonal morphological variation, but lichens do not retain all contaminants in the same way or over the same time frame. Mobile elements like nitrogen, sulfur, and potassium are both easily absorbed and leached, maintaining a dynamic equilibrium with seasonal changes in the availability of these nutrients. Chemical properties of other elements (e.g., lead and cadmium) may cause them to bond to lichen surfaces and may take years to decrease in concentration after the source has been removed.

SEAN is repeating a lichen-based, airborne contaminants study completed in 1999 at KLGO and assessing trends in key pollutants as part of the development and testing of monitoring methodologies. That study demonstrated that sulfur, nitrogen, and heavy metal concentrations in the KLGO and Skagway area exceeded thresholds established by the USDA Forest Service for southeastern Alaska (*Furbish et al. 2000*).

Some lichen species are more susceptible to the effects of nitrogen (fertilization), sulfur (acidification), and some metal-containing air pollutants compared to vascular plants. Some lichens decline in abundance or vanish from a plant community when exposed to low levels of oxides of nitrogen and sulfur, while other lichen species thrive in fertilized or acidified condition. To examine how species-specific responses to contaminants may be reflected on the landscape, SEAN is participating in lichen community studies that examine the composition of lichens in areas exposed to different levels of air pollution.

Conclusion

Global human population is expected to reach 9 billion in the next 40 years. Although most of this growth and the associated industrial development will occur at temperate and tropical latitudes, global deposition patterns and bioaccumulation processes spread the effects worldwide. The Alaska I&M networks are establishing monitoring programs with dual objectives of trend detection of chronic contamination in marine, freshwater, and terrestrial systems, as well as providing reference data that will be invaluable in the event of an acute contamination event, such as a spill. These data will allow scientists to better understand how contaminants travel great distances, enter local ecosystems, and move up local food chains and will help managers and policy makers as they meet local, regional, national, and international obligations to protect ecosystem and human health.

NPS photograph by Brendan Moynahan

Figure 3. Bay mussels (Mytilus trossulus) and barnacles (*Balanus spp.*) at the Glacier Bay Field Station in Juneau.

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